

Impact of Cost Escalation on Power System R&D Goals



Re-baselining APS, CS & FC GPRA Goals

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Outline

- **Overview**
 - R&D Goals and Baselines considered
- **Cost Escalation Trends**
- **Technology R&D Goals**
 - Snapshot in 2000/2002
 - Re-establishing the Baseline for FY2008
 - Clarifying the COE baseline
 - Updating cost for escalation
- **Summary of GPRA R&D Goals as Updated 06/08**



Overview



Advanced Power Systems (APS)

- **Cost Goal**

- Power plants more expensive today than in 2003 when goal was formulated
 - Propose to raise the capital cost goal from \$1,000/kW to \$1,540/kW (2007\$)
 - Specify cost as “overnight construction cost”

- **Efficiency Goal**

- No changes proposed to APS efficiency goal
 - 45-50%, HHV
 - *Commercial scale deployments indicate actual baseline efficiency of 35%, rather than original assumption of 40%. Therefore, will likely reach lower end of this efficiency range.*



Carbon Sequestration (CS)

- **COE Goal**

- No changes proposed to CS COE goal
 - Relative goal ...ensure advanced case and baseline compared with same year dollar and financial assumptions
- Propose following clarification
 - COE goal is relative to a baseline IGCC power plant
 - CO₂ capture level is 90%
 - COE cost includes capture, compression, transport, storage and monitoring

Fuel Cells (SECA FC)

- **FC Module Cost Goal**

- Materials more expensive today than in 2000 when goal was formulated
 - Propose to raise the capital cost goal from \$400/kW to \$700/kW (2007\$)
 - Specify that this is an overnight installed cost
 - Maintains par with NGCC costs

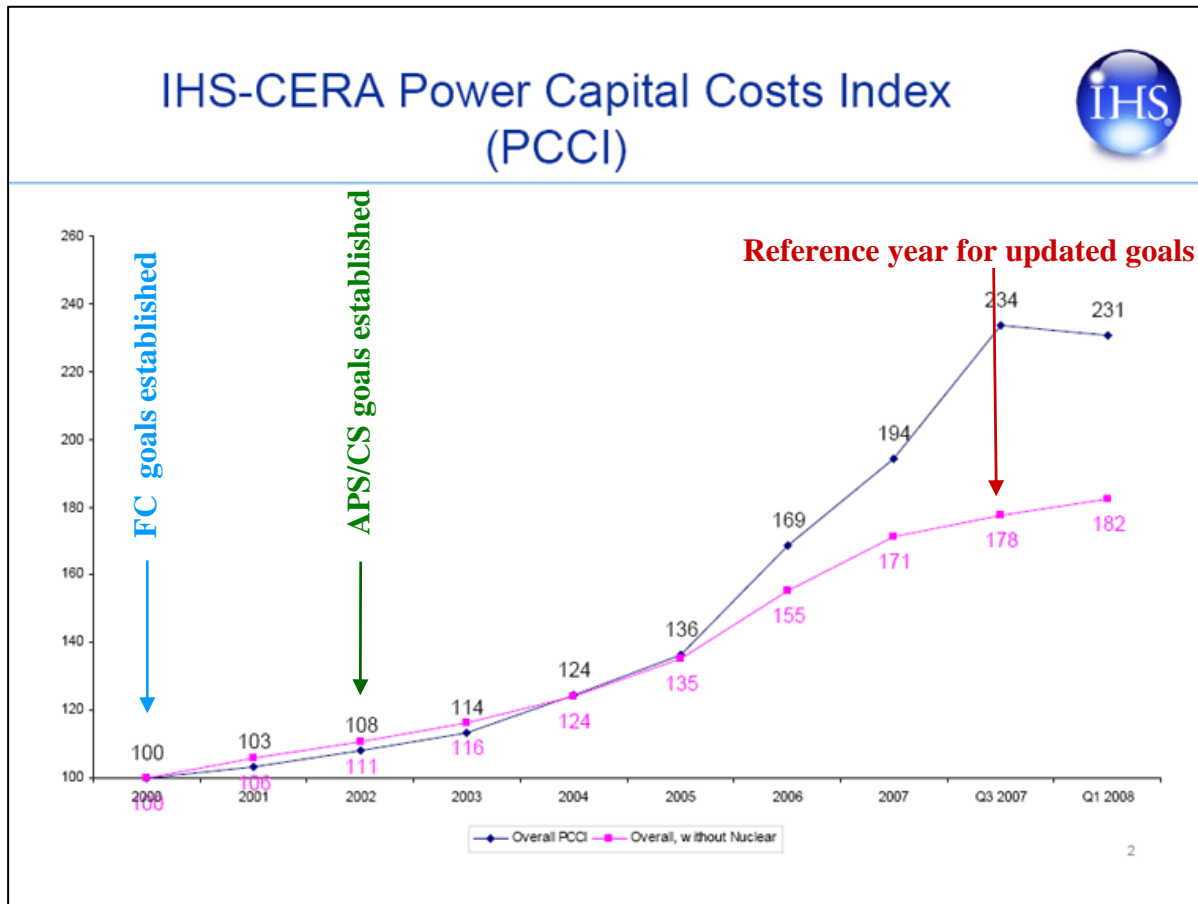
Cost Escalation Trends



Power Plant Cost Trends

- **Power plant construction costs have risen at rates greater than that of inflation in past few years**
- **Why?**
 - Global demand for electricity infrastructure-related items
 - High fuel and labor prices
 - High raw material prices
- **Expected to worsen**

CERA PCCI



- Costs increased by 78% between 2000 and 2007
– FC
- Costs increased by 60% between 2002 and 2007
– APS/CS

Advanced Power Systems



Advanced Power Systems (APS) GPRA goal

- **By 2010, develop advanced coal-based power systems capable of achieving 45-50 percent thermal efficiency at a capital cost of \$1,000 per kilowatt or less.**
 - Goal did not specify whether the thermal efficiency was on a higher or lower heating value basis, did not define the capital cost components, and did not specify the year dollars for the \$1000/kW goal
 - Baseline and goals are in constant dollar terms (inflation not considered)



Advanced Power Systems

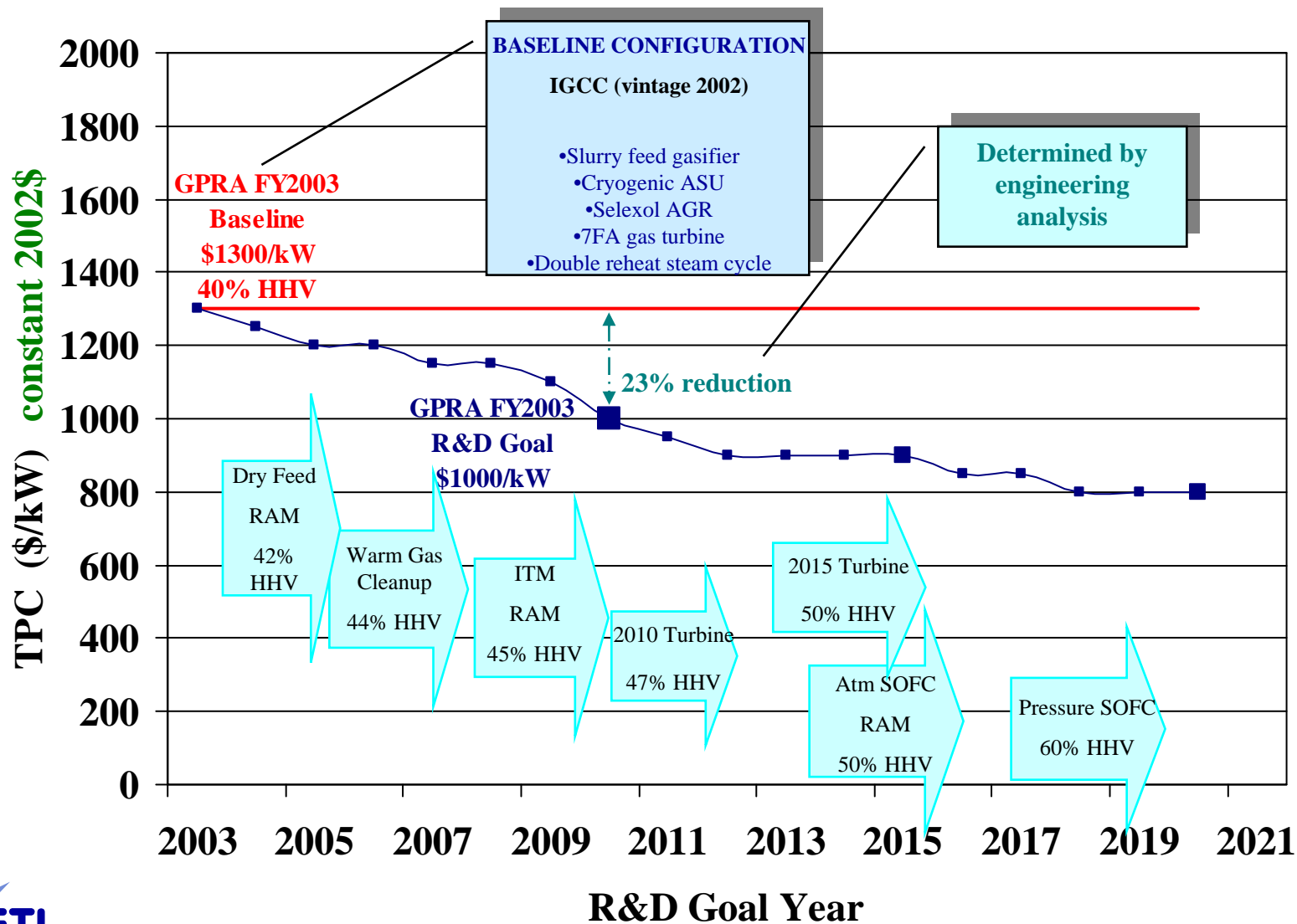
GPRA Goal History

- **Circa 2000...baseline was set**
 - COE was 4.5 cents/kWh (2002\$, baseload)
 - TPC \$1324/kW* (2002\$)
 - Efficiency of 40 percent (HHV)
- **2003...goals were set based on what is technically achievable**
 - Mitretek Study commissioned by Gasification Team
 - Technically achievable for R&D to
 - reduce TPC by 23 percent to \$1000/kW (2002\$)
 - Increase efficiency by 10 points

* Actual value of \$1200/kW (1998\$) from 1999 Market-Based study.



Snapshot of 2002



GPRA Goal Baseline

(updated June 2008)

IGCC plant vintage 2003 (slurry gasifier, 7FA turbine)

- Plant net efficiency (HHV) of 35 percent
- Total plant cost^a of \$2,100/kW (2007\$)
- 20-year levelized COE of 9 cents/kWh (2007\$)

^a Expressed as overnight construction cost (bare erected costs, engineering costs, and contingencies). Not included are owners costs such as project development fees, land and site infrastructure improvements, pre-production costs, inventory capital, and allowance for funds used during construction. With these costs included, the total capital required would be equivalent to roughly \$3,500/kW.

Re-baselined APS Cost Goals

(June 2008)

- Apply factor of 1.6 (based on CERA PCCI)
- Maintains same incremental reduction for targets
- Baseline plant configuration unchanged from FY2003

GPRA FY2003 Cost Milestones (\$/kW)	
GPRA Target Year	GPRA Goal* 2002\$
2003 Baseline	1,300
2005	1,200
2006	Not Defined
2007	1,150
2008	1,150
2009	1,100
2010	1,000

Updated Cost Milestones (\$/kW) (as of 06/08)	
GPRA Target Year	GPRA Goal* 2007\$
2007 Baseline	2,100
2007	1,850
2008	1,850
2009	1,800
2010	1,600

* Expressed as overnight construction cost (bare erected costs, engineering costs, and contingencies). Not included are owners costs such as project development fees, land and site infrastructure improvements, pre-production costs, inventory capital, and allowance for funds used during construction. With these costs included, the 2010 goal would be roughly equal to \$2,500/kW.



APS GPRA Goal

(as of 06/08)

By 2010, develop advanced coal-based power systems capable of achieving 45-50 percent thermal efficiency^a at a capital cost^b of \$1,600/kW or less (2007\$).

^a HHV basis

^b Expressed as overnight construction cost (bare erected costs, engineering costs, and contingencies). Not included are owners costs such as project development fees, land and site infrastructure improvements, pre-production costs, inventory capital, and allowance for funds used during construction. With these costs included, the total capital required would be equivalent to roughly \$2,500/kW.

Carbon Sequestration



Carbon Sequestration (CS) GPRA goal

- **By 2012, complete R&D to integrate this technology with CO₂ separation, capture, and sequestration into a “zero” emission configuration(s) that can provide electricity with less than a 10 percent increase in cost of electricity.**
 - Goal language did not include definition of baseline for COE increase
 - Baseline and goals are in constant dollar terms (inflation not considered)



Carbon Sequestration GPRA Goal History

- **1997**
 - Reduce cost of carbon sequestration to \$10 net per ton of carbon emissions
 - Criticized as overly aggressive and likely unattainable
 - 3-4 percent increase in COE (a greater than 90 percent reduction in capital cost!)
- **Circa 2001**
 - Switch to COE metric (efficiency and cost)
 - **% increase relative to conventional IGCC**
 - Estimated COE increase at 30% with CCS
 - Goal to reduce to only 10% increase by 2012



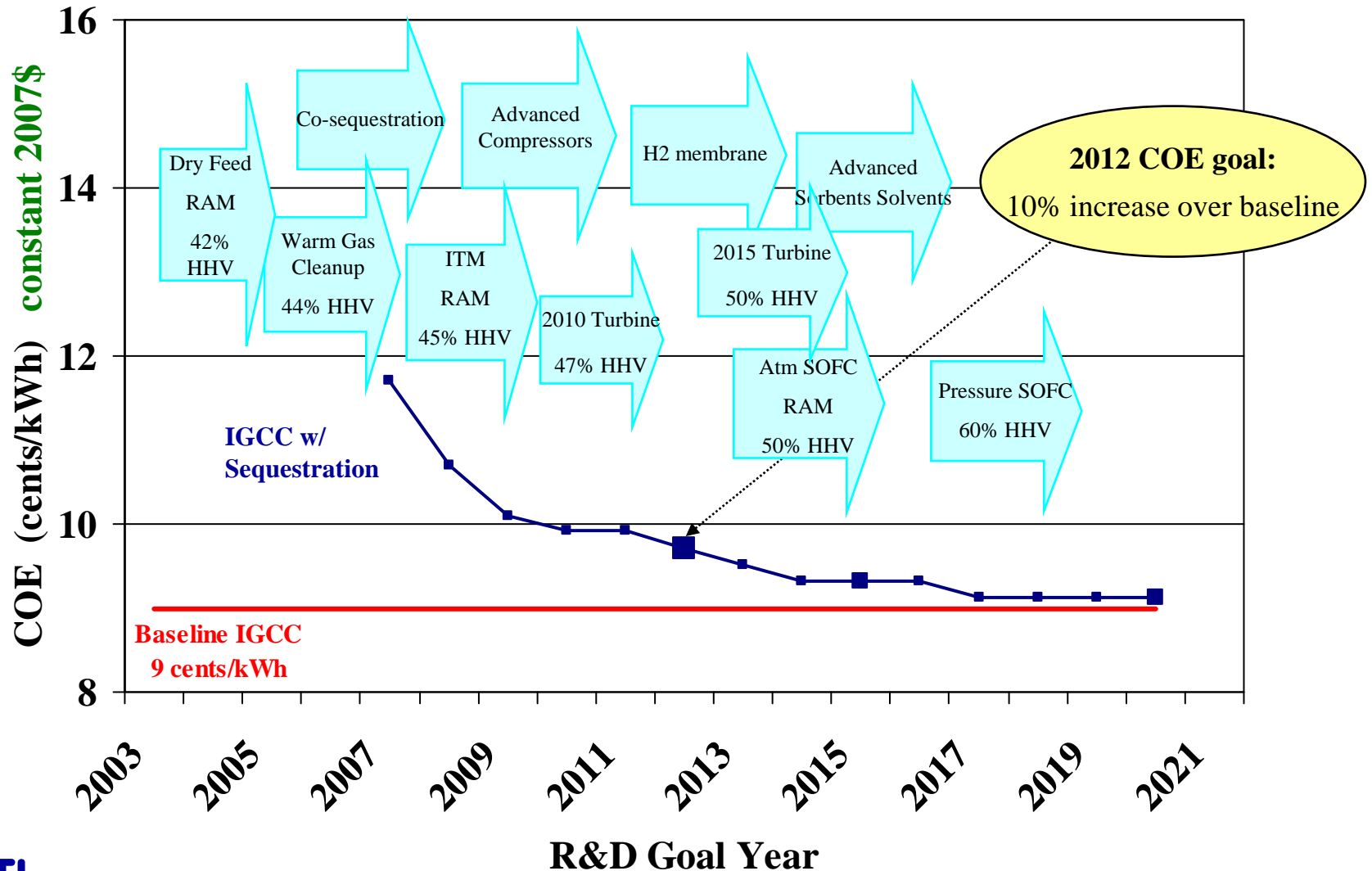
Defining the COE Baseline

To determine % change in COE:

- **Baseline** defined as IGCC plant vintage 2003
 - slurry gasifier, 7FA turbine
- To determine change in COE, divide **IGCC w/CCS** by the **baseline**

$$\left[\frac{\text{COE (IGCC w/ CCS)}}{\text{COE (Baseline IGCC)}} - 1 \right] \times 100\% = \% \text{ change in COE}$$

Integrated R&D Needed to Reach COE Goals



CS GPRA goal

(as of 6/08)

By 2012, complete R&D to integrate this technology with CO₂ separation, capture, and sequestration into a “zero” emission configuration(s) that can provide electricity with less than a 10 percent^a increase in cost of electricity^b.

^a Compared to the COE for a conventional IGCC (circa 2002); estimated to be 9 cents/kWh (2007\$)

^b COE should include costs for CO₂ capture (90%), compression, transport, storage and monitoring.

Fuel Cells (SECA)

Fuel Cell (FC) GPRA goal

- **By 2010, produce 3-10 kW solid oxide fuel cell (SOFC) modules having a capital cost of \$400/kW and, by 2015, demonstrate MW-class fuel cell/turbine hybrids, using aggregated SOFC modules adaptable to coal and having a capital cost of \$400/kW.**
 - Goal did not specify the year dollars for the \$400/kW goal, nor did it specify if installed cost or manufactured cost
 - Baseline and goals are in constant dollar terms (inflation not considered)

Fuel Cell GPRA Goal History

- **2000**
 - Solid State Energy Conversion Alliance (SECA)
Fuel Cell module capital cost goal set at \$400/kW
 - Basis: average price of combined cycle gas turbines
 - 2010 SECA fuel cells expected to compete with commercial NGCCs on capital cost basis
 - In 2000, NGCC capital cost was \$400/kW (2000\$)
 - Ultimately, SECA FC expected to be deployed in gasification-based systems where it will replace the conventional combined cycle turbine system in an IGCC configuration

Re-baselined FC Cost Goals

(June 2008)

- Cost compared to NGCC (installed cost)
- Apply factor of 1.78 (based on CERA PCCI)
- Maintains same incremental reduction for targets

GPRA FY2003 Cost* Milestones (\$/kW)	
GPRA Target Year	FY2003 GPRA 2002\$
2003 Baseline	4500
2005	800
2008	600
2010	400

Updated Cost* Milestones (\$/kW) (as of 06/08)	
GPRA Target Year	GPRA Goal 2007\$
2007 Baseline	>8,000
2008	1,050
2010	700

*Fuel cell system module cost expressed as overnight construction cost (specifically, bare erected costs, engineering costs, and contingencies).

FC GPRA Goal

(as of 06/08)

By 2010, produce 3-10 kW solid oxide fuel cell (SOFC) modules having a capital cost of \$700/kW (2007\$) and, by 2015, demonstrate MW-class fuel cell/turbine hybrids, using aggregated SOFC modules adaptable to coal and having a capital cost of \$700/kW (2007\$).*

*Based on 2007\$ cost of NGCC in terms of overnight construction cost (bare erected costs, engineering costs, and contingencies).

Recommendations

- 1. Provide a consistent framework for determining the level of progress made in the research program**
 - Clearly define and benchmark the baseline
- 2. Update GPRA goals when necessary to reflect market conditions**
 - Account for cost escalation and inflation
 - Review annually to determine if trends shift significantly



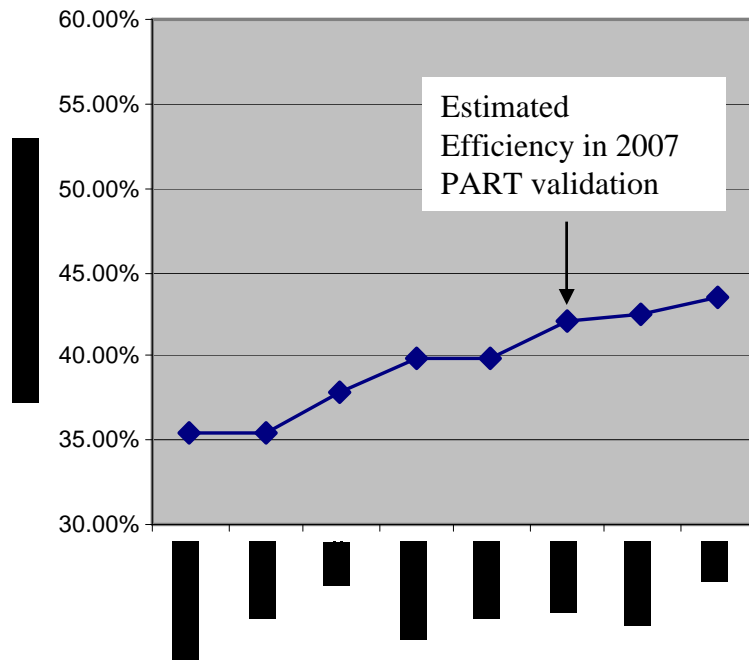
Extra Slides



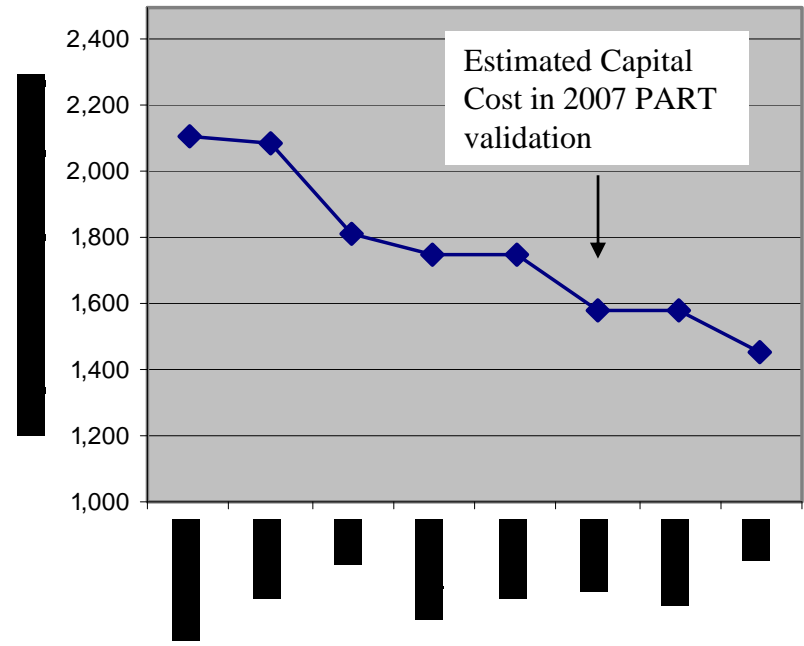
Efficiency and Cost Usually Inversely Proportional

But: APS goals must be achieved simultaneously!

R&D Cumulative Impact on Efficiency



R&D Cumulative Impact on Capital Cost



PART Input vs. Re-Baseline Study

- **APS & CS Baseline Costs in 2007\$**
 - PART Study TPC= \$1940/kW COE= 8 cents/kWh
 - Re-Baseline TPC= \$2100/kW COE= 9 cents/kWh

Escalated Capital Cost Goal for APS (\$/kW)				
FY	GPRA 2002\$	2007 PART 2007\$	Re-baseline	
			2002\$	2007\$
2003	1,300	1940	1800	2100
2005	1,200	1788		
2006	-	-		
2007	1,150	1714	1600	1850
2008	1,150	1714	1600	1850
2009	1,100	1639	1550	1800
2010	1,000	1490	1400	1600



PART Input vs. Re-Baseline Study

- PART report suggested changes to APS efficiency goal and CS COE goal
 - Re-baselining analysis determined that no changes are required to these goals

